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LAND USE CONSTRAINTS ON WETLAND BIOMASS DEVELOPMENT

A Case Study in Aitkin County Minnesota

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ABSTRACT

The University of Minnesota is working on a comprehensive study of wetland biomass development in the state. This paper deals with one aspect, land available for growing the biomass, in a pilot county. A list of potential land use conflicts and geographically significant economic limitations was developed through discussions with knowledgeable people in many public agencies and colleagues within the University. These constraints are then overlaid on the wetland base, both individually and in combinations in models for alternative development strategies, to estimate the amount of land area remaining available for biomass development. While large acreages remain unconstrained, a majority are eliminated in these models. Significantly more lands could be made available with appropriate technological breakthroughs and public policy decisions.

Biomass could provide an answer to this country's energy problems. If an easily transportable fuel could be produced in great quantities at a competitive price, biomass could reduce or eliminate our dependence on the vagaries of foreign petroleum supplies while improving our balance of payments. The use of biomass would reduce the problem of degrading our atmosphere with the carbon-dioxide produced when burning fossil fuels. If the biomass itself could be grown on land not otherwise useful, these large benefits could be gained at little cost to society.

These are the reasons behind the Wetland Biomass Project at the University of Minnesota. The project is a comprehensive study and is funded by the state of Minnesota. Botanists are looking at various wetland plants, especially cattails, to determine which plants are most efficient at converting sunlight into biomass and the conditions under which these plants are best grown. Initial results appear promising, with cattails producing about twice as much biomass per acre as corn. Agricultural engineers are looking at ways to harvest these wetland crops. Biochemists are studying ways to convert the crops into a useful energy source. Economists are making certain that choices made produce results that are economically viable.

Availability of land for growing the biomass is the subject of study for land use planners at the University's Center for Urban and Regional Affairs (CURA). How many acres of wetlands exist in Minnesota? After allowing for economic constraints and land use conflicts, how many acres actually could be considered available for production? What effect on land availability would result from selecting alternative technologies? How could changes in public policy affect this availability? The answers to these questions are key to the viability of any notion of a wetland biomass industry in Minnesota. For example, if harvesting technology requires draining an area before moving in the equipment, no development will take place if it turns out that most wetlands are distant from rivers or lakes.

This paper will describe the study of wetland availability in Minnesota. Some of the results are relatively solid, others are more subject to speculation. Perhaps more important than the results is the process used. No one knows just how wetland biomass development might take place. Understanding and knowledge are gained through a circular and cumulative process involving all researchers and policy makers. A small breakthrough by one actor allows another to move forward in his work and so on until the first actor can take another step forward.

The land use research effort required extensive use of maps. Maps had to be interpreted and overlaid with other maps. Geographical manipulation of the maps was also required as when determining distance to a key resource such as open water. These tedious and time consuming tasks were easier because of access to a geographic information system, the Minnesota Land Management Information System. MLMIS was developed under CURA and is now housed in the State Department of Energy, Planning and Development. It consists of a data base of commonly used maps stored in the computer as grids, with each cell classed as a single dominant value for each map. Other maps can be easily added to the data base. The cell is 40 acres in size. MLMIS also has the capability of manipulating and combining these maps. Results may be produced as tables or maps. The maps in this paper were all produced by MLMIS on an electrostatic plotter.

MINNESOTA'S WETLAND BASE

The first question to be answered was how many acres of wetland exist in Minnesota. No source exists which could provide a ready answer to this question. The closest thing to an estimate was a figure of 7.5

million acres of peatland used by the Minnesota Peat Project in the Department of Natural Resources. Satellite sensings available to the public through NASA's Landsat program are effective for locating open water, but not wet areas covered by vegetation.

The alternative was to identify wet soil in the Minnesota Soil Atlas. These generalized maps provide the only set of soil maps for the state. Peat soils are designated. All mineral soils are classified by a number of characteristics including whether or not the soil was well or poorly drained in its natural state.

Peat and wet mineral soils were mapped and areas tallied. A total of 18.4 million acres of wet soils were identified, more than one-third of the total land area of the state. Wet soils were found in all parts of the state. Of the total, 5.9 million acres of peat were identified, mostly in northern Minnesota. Note this figure is considerably below the 7.5 million acre estimate which had been used by those investigating peat mining. Another 12.5 million acres of wet mineral soils existed largely in south-central and northwestern Minnesota.

The natural state of these soils has not prevailed in many parts of Minnesota. Many of these wetlands are now drained and producing agricultural crops at a rate exceeded few places in the world. Most affected by drainage were wet mineral soils which were reduced 65 percent to 4.4 million acres. Peat soils experienced a 9 percent drop to 5.4 million acres due to drainage. These estimates were made by overlaying a current land use map and a map indicating parts of the state where even pasture lands have been improved by drainage. In total, a significant 9.7 million acres, or 18 percent of the state, remains in its wet natural state. These lands are concentrated in the northern part of the state.

Most of this land is in public ownership. Private landowners hold only 39 percent and various Indian land holdings amount to another 5 percent. Indeed the state owns 38 percent directly, while counties hold another 12 percent, most of which are actually deeded to the state through tax forfeiture. The federal government owns 6 percent.

CONSTRAINTS ON WETLAND AVAILABILITY

The existance of wetlands does not guarantee their availability for growing biomass crops. Other constituencies may have designs on portions of this land for wildlife or timber production. Two-thirds of the wetlands currently are forested. In such an instance a land use conflict may result. Other portions may be too isolated or unproductive to be economically viable for biomass production.

These two forces, land use conflict and economic limitations must be considered as constraints on land available for wetland development. The nature and extent of these constraints is not clear. Internal discussions generated an initial list of conflicts and restrictions. The problem was then discussed with a large number of public planners, technicians, and policy makers in order to expand and refine the list of constraints. During these discussions, participants were also asked to assist in locating a map or interpreting an existing map to best show the geographic extent of each constraint. The point of this exercise was twofold. We desired as much expert opinion as possible. We also wanted to make contacts and build a constituency within various departments and agencies. The list of constraints is given below:

LAND USE CONFLICT

- Human Settlement
- Commercial Forestry
- Expansion Agriculture
- Outdoor Recreation
- Wildlife
- Unique Natural Areas
- Historic Sites
- Mining - Minerals
- Mining - Peat
- Owner Restrictions

ECONOMIC LIMITATION

- Productivity
- Water Access
- Road Access
- Access to Agriculture
- Management Unit Size

The impact of these constraints was then studied in a pilot county. Aitkin County in northeastern Minnesota was chosen for a variety of reasons. Of all the counties with large wetland acreages, it is closest to the Twin Cities. Both state government personnel and University researchers were therefore familiar with the area and would be most able to give advice and react to results.

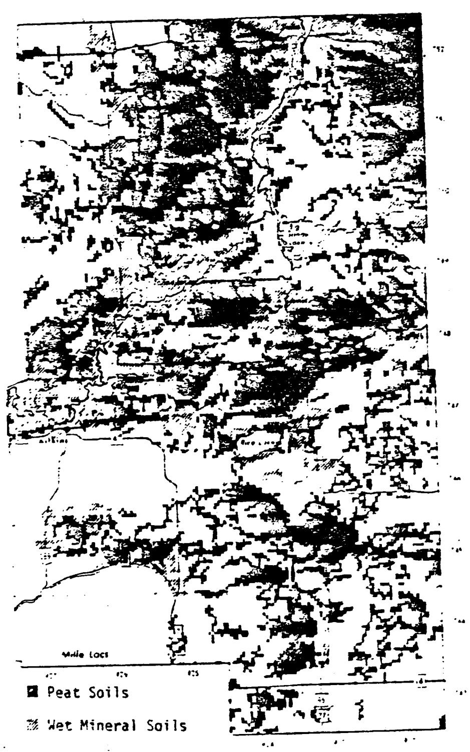

FIGURE 1. WETLAND BASE

Nearly half of Aitkin County remains covered with wetland: see Figure 1. Of the 445,300 acres of peatland, 427,300 (or 96 percent) remain in the wetland base. Of the 179,200 acres of poorly drained mineral soils, 141,200 (or 79 percent) remain in the wetland base. In all, this wetland base contains 568,500 acres.

In the remainder of this section, the impact of each constraint on this wetland base will be shown. In each case, the constraint map will be presented. The impact of the map on the wetland base will be noted in the text as if the constraint won out in every case. While this may not be realistic, the relative importance of each constraint on wetland availability can be shown.

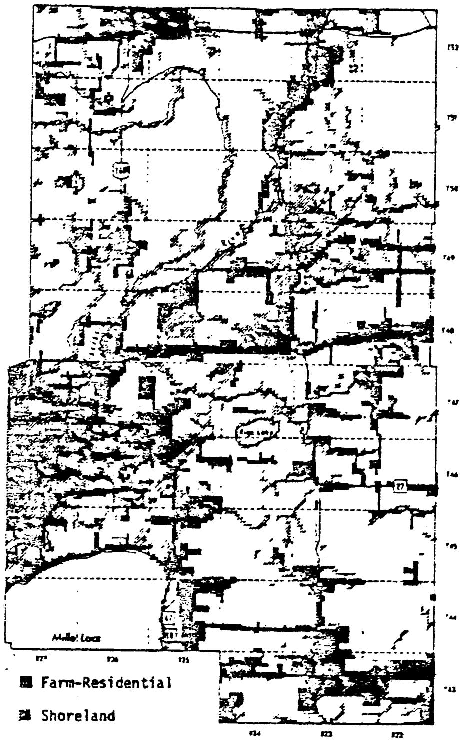

FIGURE 2. HUMAN SETTLEMENT: COUNTY ZONING DISTRICTS

Human Settlement

The citizens and government of Aitkin County have carefully determined which areas of the county they wish to perserve for human settlement. Their plan has been embodied in the county zoning ordinance and zoning maps. Two areas are set aside for human settlement: farm-residential and shoreland (see Figure 2). Within these areas, conditional use permits are required for constructing facilities such as dams, reservoirs, and canals which may be essential in biomass operations.

The ordinance and map were prepared before anyone seriously considered biomass development, so constraints might be much smaller than shown here. If no development were allowed in these zones, 126,700 wetland acres (or 22 percent) would be unavailable.

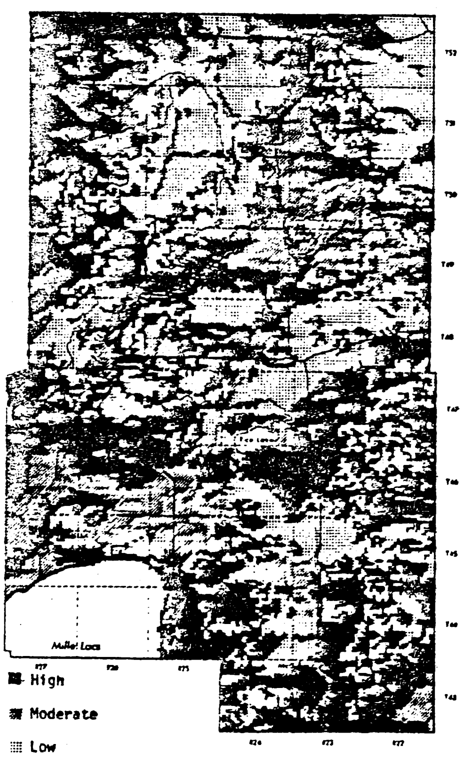

FIGURE 3. COMMERCIAL FORESTRY: SOIL PRODUCTIVITY FOR KEY SPECIES

Commercial Forestry

Many factors determine what lands might be best suited for commercial forestry. They include current tree variety and size, road access, and soil productivity. The Minnesota Department of Natural Resources has restricted its concerns to soil productivity and, therefore, so will this analysis. Their forest productivity map is shown in Figure 3. These ratings are always tied to the most productive tree species and are therefore most useful for long term management. Short term conflicts may prove no problem, since clearing timber would be a necessary first step in preparing land for biomass production. If only the most productive soils for trees were removed from the wetland base, 141,200 acres (or 25 percent) would be unavailable.

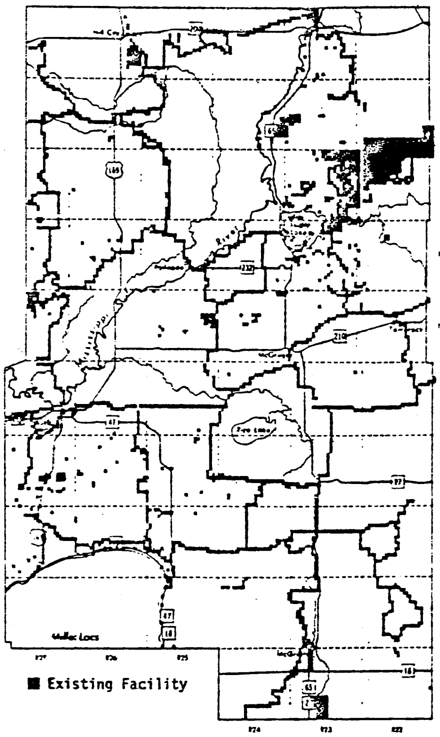

FIGURE 4. OUTDOOR RECREATION

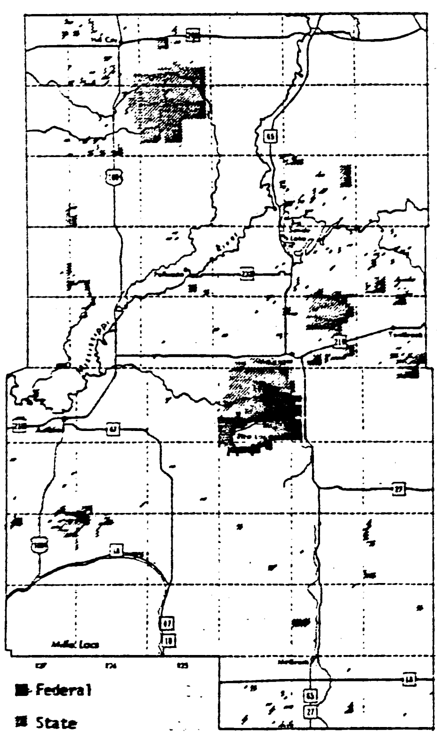

FIGURE 5. WILDLIFE: REFUGES

Expansion Agriculture

No agreed upon model could be developed for agricultural expansion in Aitkin County. In the past decade, agriculture has expanded considerably in the county, but the location of this activity seems more dependent on the resources and whims of individual landowners than on the physical characteristics of the developed land. No constraint is shown. Indeed, there need not be a constraint, since biomass production could be considered a form of agriculture.

Outdoor Recreation

Outdoor recreation, on the other hand, has a constituency that probably would fight the conversion of "their land" to another use. The Department of Natural Resources maintains an inventory of all recreation facilities in the state. Included are trails, campgrounds, water access, parks and public forests. We excluded the portion of these forests where recreation was not the highest recommended use. These existing outdoor recreation facilities are shown in Figure 4. They overlay 50,900, or 9 percent, of the wetland base.

Wildlife

Another conflicting use which has a large constituency is wildlife. For example, cattails provide poor habitat for water fowl. The rating of lands for their suitability for wildlife could be complex and fraught with conflict. A significant portion of Aitkin County is already set aside for wildlife in federal or state refuges: a total of 87,000 acres. These refuges are shown in Figure 5. It may be that these refuges are all the land which activists could politically hope to preserve for wildlife. Were this the case, 68,000 (or 10 percent) of the wetland base would be unavailable for development.

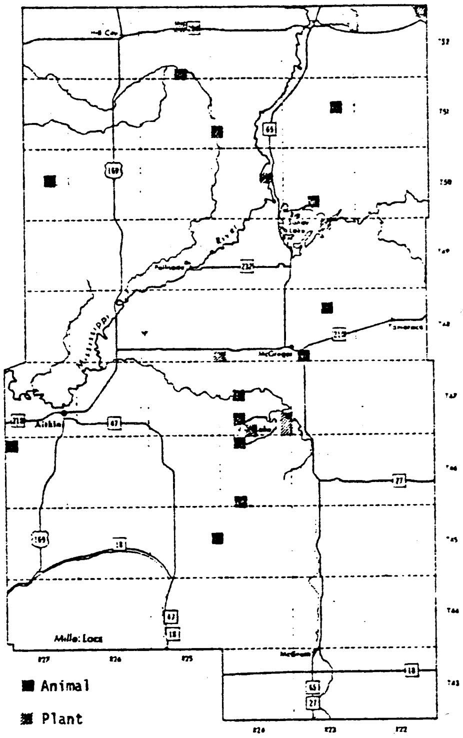

FIGURE 6. UNIQUE NATURAL AREAS: SECTIONS CONTAINING IMPORTANT COMMUNITIES

Unique Natural Areas

Conservation groups will also strongly oppose conversion of unique natural areas. In some cases these may be breeding or feeding areas for rare animals such as cormorants or eagles. In others, unique plant communities may be worthy of preservation. The Minnesota Natural Heritage Program is cataloging these unique natural areas. To date, the program has identified unique natural sites within 21 different sections (one square mile) of Aitkin County; see Figure 6. If the entire 640 acre section around each of these sites were excluded from development, 7,400 acres (or 1 percent) of the wetland base would be unavailable.

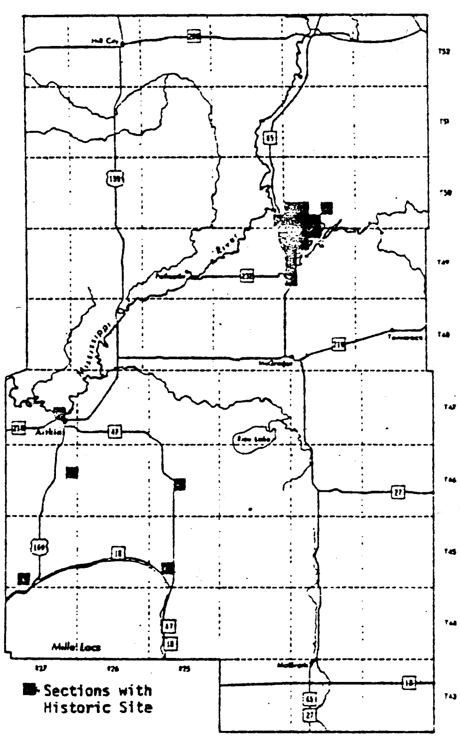

FIGURE 7. HISTORIC SITES

Historic Sites

Also worthy of preservation are historic sites containing important cultural artifacts. In Aitkin County, all such sites are Indian mounds. In order to prevent disclosure and possible pilfering, the Minnesota Historical Society prefers to present only generalized maps of the locations of these sites. Twenty sections containing Indian mounds are shown in Figure 7. If the entire 640 acre section were excluded from development, only 1,400 acres (less than 1 percent) of the wetland base would be unavailable.

Mining - Minerals

Mining could also present a land use conflict. Though no mineral mining is currently underway in Aitkin County, future activity might disrupt the landscape, removing wetlands. The Minerals Division of the Minnesota Department of Natural Resources states that iron, manganese, and sulfur deposits do exist in Aitkin County but under current technology mining cannot be economically justified. For this reason, surveying and mapping of the potential resource has not been precise. Figure 8 presents a very rough map of the possible extent of geologic formations which may contain significant deposits of these important minerals. Were all of these subsequently taken out of the wetland base, 72,600 acres (or 14 percent) would be unavailable for development.

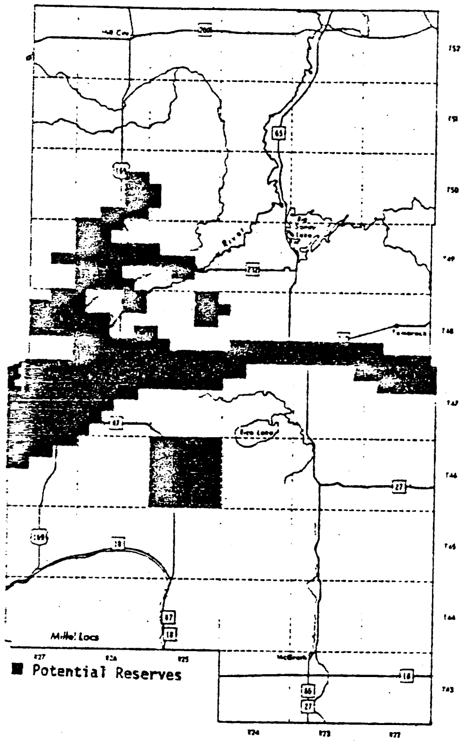

FIGURE 8. MINING--MINERALS

Mining - Peat

Peat mining for energy offers another potential land use conflict. The Minnesota Peat Project, again in the Department of Natural Resources, has determined that peatlands must be five or more feet in depth and of a type other than sphagnum in order to be economically mined. Most peatlands pass this test: see Figure 9. Whatever conflict results, however, could be short-term. If some peat were left and water levels maintained, areas mined for their peat could have a subsequent use for biomass production.

If peat were commercial mined, 426,100 acres (or 75 percent) of Aitkin County's wetland base would be unavailable for development at some time or other. If not properly restored, these lands could be permanently lost.

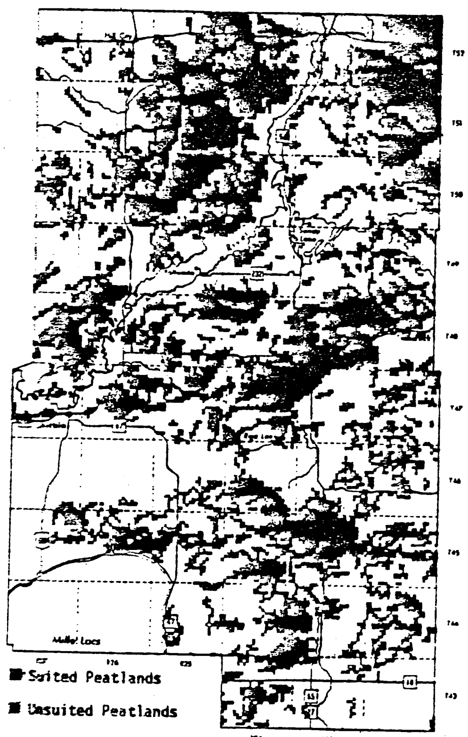

FIGURE 9. MINING--PEAT

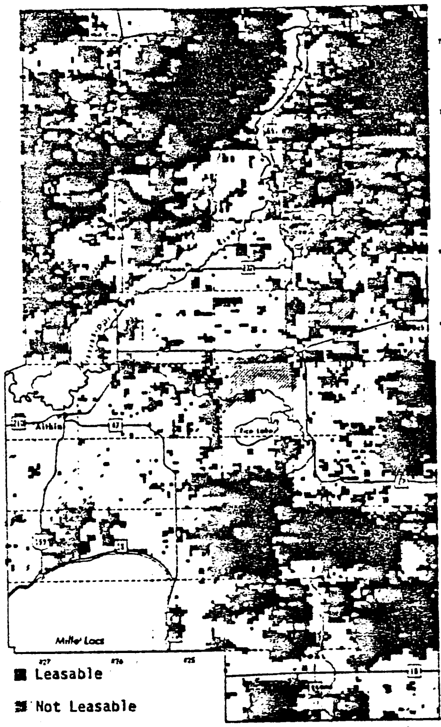

FIGURE 10. OWNER RESTRICTIONS: LEASABILITY OF STATE AND COUNTY LANDS

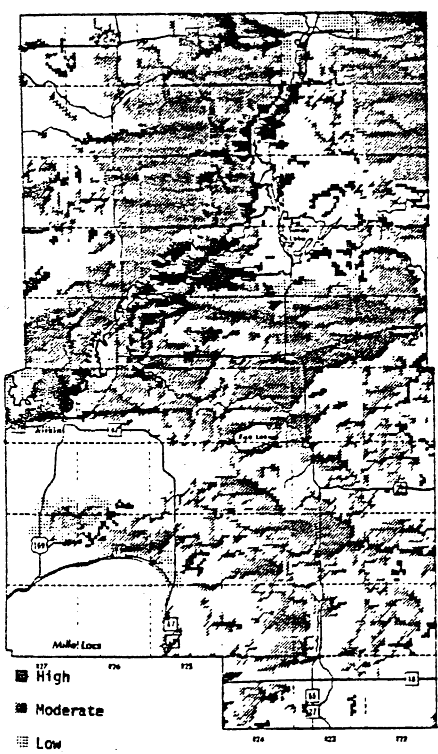

FIGURE 11. PRODUCTIVITY: WETLAND CROP PRODUCTIVITY

Owner Restrictions

Some owners may refuse to let their lands be used for biomass development. The Minnesota Peat Project saw this as an obstacle to mining peat. Through agency contacts, the Project identified state and county agencies and divisions which would not lease their lands for peat extractions. Largely overlapping management practices considered above (e.g. Wildlife lands), the explicit statement of the unavailability of these lands is presented here to make the point that policies do exist which will limit biomass development. While the state and county own nearly half the land in Aitkin, the data presented here must ignore the policies and predilections of the majority of owners: private individuals and the federal government. For those lands where a decision on whether to make lands available for peat development through a lease, something can be inferred about their availability for biomass development. Figure 10 shows the state and county lands which would and would not be available for lease. Were these excluded, 24,500 acres (or 4 percent) would be unavailable for biomass development.

Productivity

Inherent soil productivity is an important economic consideration for biomass development. Money spent on expensive fertilizer could be saved, perhaps making the entire venture profitable, were the most fertile soils used. Preliminary productivity ratings of the wet soils in the Minnesota Soils Atlas have been prepared by a faculty member of the University's Department of Soil Science. The productivity of wet soils in Aitkin County is described in Figure 11. Were the least fertile wet soils excluded from development, 56,300 acres (or 10 percent) of the wetland base would be unavailable for biomass development.

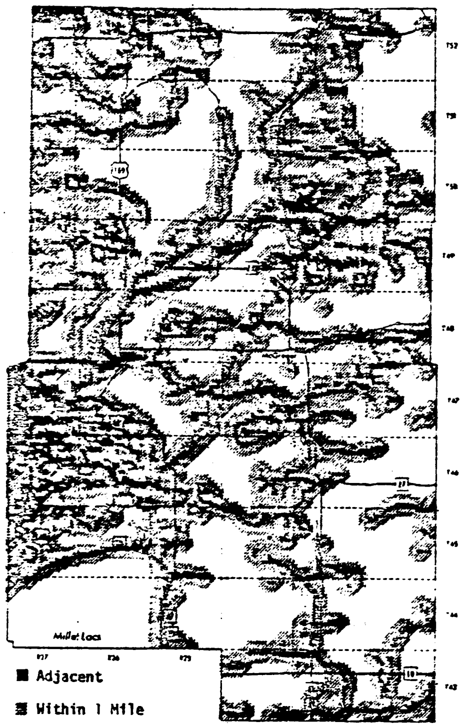

FIGURE 12. WATER ACCESS: PROXIMITY TO PERMANENT WATER

Water Access

Planting and harvesting technology could restrict wetland biomass development to those locations in close proximity to a permanent lake or stream. Areas may need to be drained for harvesting, then flooded again. Lands farther from water would require more extensive capital investment in pumps, canals, and pipes. Again, this extra expense could render the entire operation uneconomical. Other problems of obtaining permits for appropriation and discharge may exist. Only physical access to water is considered here.

Figure 12 indicates the lands near water in Aitkin County. Were only lands touching or within one mile of year-round water bodies available for development, 252,900 acres (or 44 percent) of the wetland base would be unavailable.

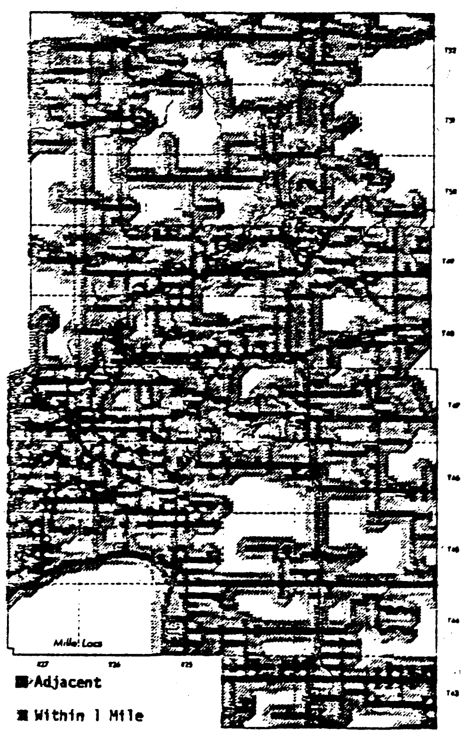

FIGURE 13. ROAD ACCESS: PROXIMITY TO ROADS

Road Access

Costs could also be kept low by limiting development to wetlands with good road access. This would facilitate moving in equipment and moving out the harvest.

Figure 13 presents lands on or near roads in Aitkin County. Were development restricted to lands with good road access, 150,800 acres (or 26.5 percent) of the wetland base would be unavailable.

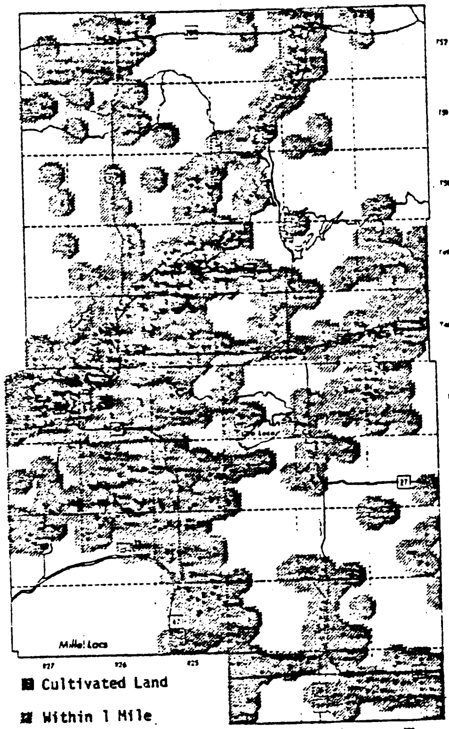

FIGURE 14. ACCESS TO AGRICULTURE

Access to Agriculture

Capital expenses and labor costs would be lower if wetland biomass development could be tied into existing farm operations. Trucks, tractors, and plows already paid for could be used. Farmers might happily use biomass income to supplement their other earnings, rather than rely solely on biomass earnings. They would not be interested in hauling equipment all over the county, but would probably like to work near existing farm operations.

Lands within one mile of cultivated land are shown on Figure 14. With development restricted to these lands, 263,200 acres (or 46.3 percent) of wetland base would be unavailable.

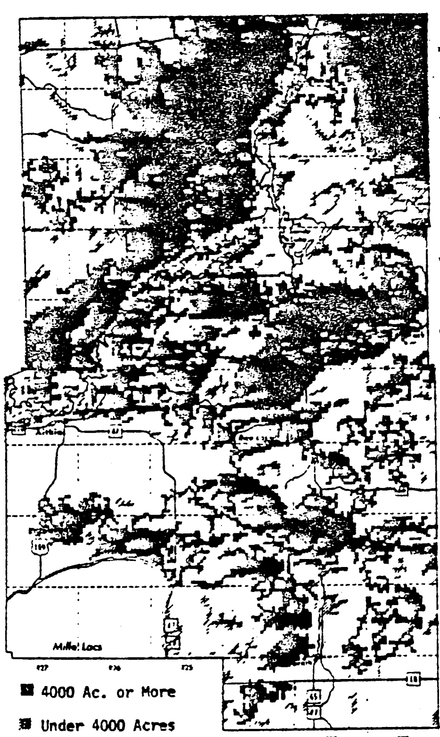

FIGURE 15. MANAGEMENT UNIT SIZE: NUMBER OF CONTIGUOUS WETLAND ACRES

Management Unit Size

An alternative development strategy might be large scale commercial development. Here the developer would undoubtedly want a large wetland area which could be managed as a single unit. One thousand acres might be the minimum economic size, but the developer would probably want room to expand. Four thousand acres is taken as the minimum management unit. The large size of wetland areas in Aitkin means that even this large a management unit size has little effect on restricting the availability of land for development; see Figure 15. Were development restricted to management units of 4,000 acres or more, only 48,000 acres (or 8 percent) of the wetland base would be unavailable. If management units are to be made up of wetlands after they have been pared down by other constraints, the 4,000 acre unit will be more difficult to attain.

Summary of Constraints

Many potential constraints against the availability of wetland for biomass development exist. The above list was created by involving public officials and researchers, but may not be complete. For any one constraint the amount of wetland noted as restricted may be subject to change as research continues and biomass development comes closer to being a reality. Agencies and constituencies may spend more time defining and defending their turf. Alternatively, biomass development could become so important that it will win out over some of the conflicts and limitations.

This listing of the potential constraints and relative impacts is an important starting point for future discussions. The constraints and their impacts are summarized in Table 1. Most constraints appear to restrict relatively little land. Of the soft constraints, those which do not appear to absolutely restrict development, only peat mining, forestry, and human settlement would restrict more than 10 percent of the wetland base. Of the harder constraints only access to agriculture, water access, road access, and wildlife restrict more than this (10 percent) figure. With creative and varied development strategies, all but the wildlife constraint could probably be overcome.

TABLE 1: POTENTIAL CONSTRAINTS ON USE OF WETLAND BASE (568,500 acres)

	No Constraint		Constrained	
Land Use Conflicts	Acres (000)	Percent	Acres (000)	Percent
Human Settlement	441.8	77.7	126.7	22.3
Commercial Forestry	427.3	75.2	141.2	24.8
Expansion Agriculture	?		?	
Outdoor Recreation	517.6	91.0	50.9	9.0
Wildlife	500.5	88.0	68.0	12.0
Unique Natural Site	561.1	98.7	7.4	1.3
Historic Site	567.1	99.8	1.4	0.2
Mining - Minerals	485.9	85.5	82.6	14.5
Mining - Peat	141.4	24.9	426.1	75.0
Owner Restrictions	544.0	95.7	24.5	4.3
Economic Limitations				
Productivity	512.2	90.1	56.3	9.9
Water Access	315.6	55.5	252.9	44.5
Road Access	417.7	73.5	150.8	26.5
Access to Agriculture	305.3	53.7	263.2	46.3
Management Unit Size	520.5	91.6	48.0	8.4

WETLAND DEVELOPMENT STRATEGIES

Four models of wetland development are put forth here and compared against the constraints they might encounter. The first is simplistic. Every acre of wetland is available for development; no constraints apply. A second model takes the opposite approach, equally simplistic. In it, all reasonable constraints apply, limiting development to a very small area. The remaining two models are more realistic. One is a farm supplement model drawing on the labor and capital of agriculture to support small scale development. The other is large scale commercial development.

In each case a model is developed by applying a specific mix of constraints. For example, large management units are an important constraint for commercial development, but not for farm development. Conversely, proximity to agriculture is not important for commercial development. The constraints applied in each model are presented in Table 2 below.

TABLE 2: CONSTRAINTS APPLIED IN MODELS OF DEVELOPMENT STRATEGIES

	MODEL			
LAND USE CONFLICTS	No Constraints	Maximum Constraints	Farm Development	Commercial Development
Human Settlement		●		●
Commercial Forestry				
Expansion Agriculture				
Outdoor Recreation		●	●	●
Wildlife		●	●	●
Unique Natural Areas		●	●	●
Historic Sites		●		●
Mining - Minerals				
Mining - Peat				
Owner Restrictions		●	●	●
ECONOMIC LIMITATIONS				
Productivity		●	●	●
Water Access		●		●
Road Access		●	●	
Access to Agriculture		●	●	
Management Unit Size		●		●

A few constraints are never applied. For two, commercial forestry and expansion agriculture, the nature of the conflict is too ambiguous. For commercial forestry and peat mining, biomass development could be a subsequent use: no conflict need exist. Mineral mining is not economically feasible now and there is no indication it will be in the near future. All other constraints are applied in at least one model.

On the other hand, a few constraints apply to all models except the first. These constraints are seen as nearly absolute. They will apply in all forseeable circumstances. These constraints include: outdoor recreation, wildlife, unique natural areas, owner restrictions, and soil productivity.

No Constraint and Maximum Constraint

Little needs to be said about these two simplistic models. They define the maximum and minimum acreage which might be available for biomass development in Aitkin County. On the one hand, 100 percent of the wetland base remains available. On the other, only 3 percent remains available. Even in this very restricted model, 15,700 acres remain available for biomass development. The distribution of the lands is shown in Figures 16 and 17. The lands shown in black are wetlands available for development, while gray indicates other wetlands. White indicates other lands or water.

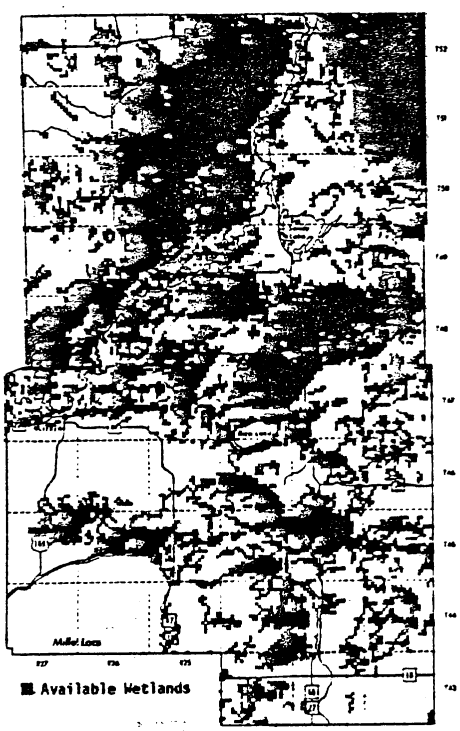

FIGURE 16. NO CONSTRAINT MODEL

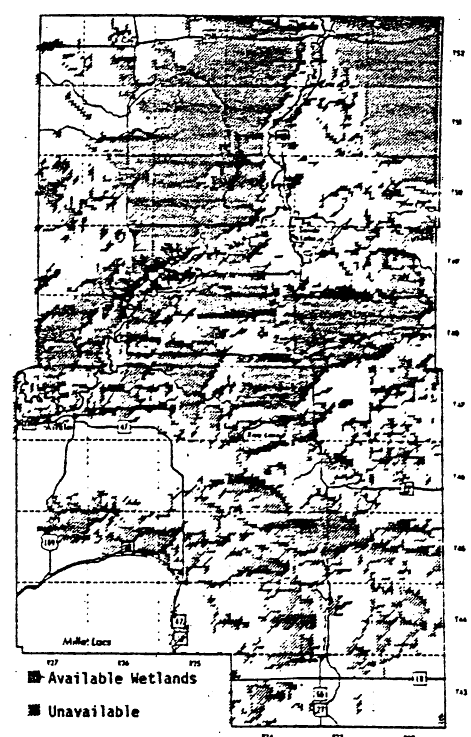

FIGURE 17. MAXIMUM CONSTRAINT MODEL

Farm Development Model

This model assumes local farmers could be drawn in to manage and harvest wetland biomass. The labor and equipment from their farm operations would be applied to moderately or highly productive wetland areas within a mile of their existing farms. Small operators cannot afford to build their own roads, so access to the road network is also important. Water access needs could probably be met through small, shallow wells and the extensive drainage ditch network found throughout the county. Large management units would be neither necessary nor desirable. As a consequence, the county would see no conflict with human settlement plans and any necessary conditional permits for development would be granted. Finally, the location and integrity of the historic sites could be entrusted to local inhabitants. These small sites could be skirted by farmers imposing virtually no reduction in available wetland acreage.

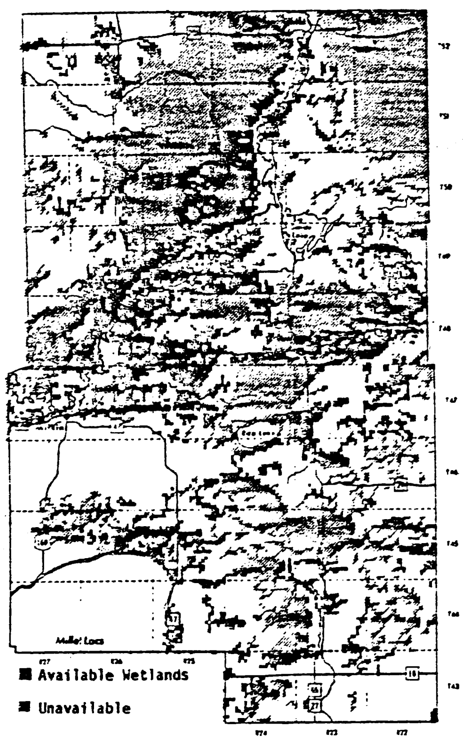

FIGURE 18. FARM DEVELOPMENT MODEL

Imposing all relevant constraints simultaneously yields Figure 18. Here 36 percent (or 205,000 acres) of the wetland base remains available for development. Access to agriculture accounts for most of the paring down. In fact, one-quarter of the paring is due to this factor alone without any other overlapping constraints. Most farms are well served by roads and so too would be nearby wetlands. Together, these two factors account for most of the paring down. Each of the other five constraints removes an additional bit of wetland until just over one-third of the wetland base could be utilized under this small scale farm supplement development strategy.

The quantity of lands developed under this strategy could be most markedly increased by convincing farmers to travel more than a mile from their existing operation or by adding farms in more isolated areas. Perhaps some of these new farmers would work biomass exclusively.

Commercial Development Model

Large scale commercial development is the other strategy considered here. Unlike the above model, large plots are required: at least 4,000 acres. Water needs are extensive so access to a permanent river, stream, or lake is necessary. The large size means operations will undergo close scrutiny by the county and possibly development will not be allowed in areas currently zoned for human settlement. Enough capital will accompany these developments to overcome problems of road access and, obviously, access to existing farming operations is irrelevant. What will be relevant, however, is the preservation of historic sites. A large area around each site, perhaps as much as a section (one square mile), will be restricted from development.

Applying all these constraints simultaneously would leave 30 percent of the wetlands available for development. The overlap with the farm development strategy would be about half, so, together, between large and small scale development, about half the county's wetland could be used for biomass development.

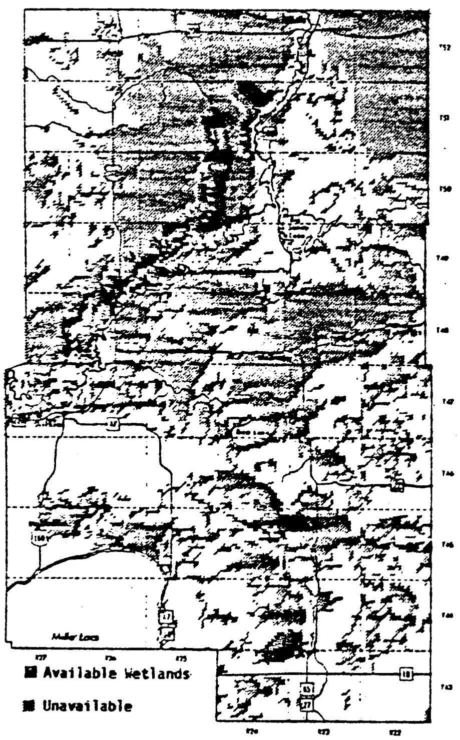

FIGURE 19. COMMERCIAL DEVELOPMENT MODEL

Unfortunately, such an outcome is unrealistic. The management unit size constraint must be applied after all other constraints since the desired outcome is 4,000 or more acres of unconstrained land. Using this approach, only 9 percent of the wetland base remains available for development: see Figure 19. A large percentage of these lands overlap the lands available for small scale development. If both large and small scale developments were attempted, under 40 percent of the wetland base could be used.

The severe reduction in lands available to large scale commercial biomass development is due most obviously to the large management unit size constraint, when applied after other constraints chop up most of the large areas. Alone, this factor accounted for a 21 percent drop. Areas reserved for human settlement and outdoor recreation were the most devastating constraints in this regard, because their linear patterns dissected many large management units. In fact, however, water access is the largest <u>single</u> restriction on commercial development. Nearly half the reduction in available wetland base is due to lack of water access.

The quantity of wetlands developed under this large scale commercial development strategy could be greatly increased if operators could use smaller management units. Units could be in close proximity, if not contiguous. If the county saw benefits in commercial operations, it could encourage development by quickly processing and approving conditional use permits where precautions against abuse of land and neighbors had been guaranteed. Finally, if technology could be developed which could economically and efficiently plant and harvest the biomass without draining or flooding the area, significantly more land could be brought into production.

CONCLUSIONS AND RECOMMENDATIONS

Plenty of land will exist for wetland biomass development in Minnesota even if all battles over land use conflicts and geographically related economic limitations are lost. The purpose of this paper, however, was to enumerate these constraints and the impact of each so that researchers and policy makers could begin working on ways to reduce the impacts of these constraints. The tasks ahead based on work in Aitkin County are presented below.

Future Research

All aspects of this research effort are related and their study must continue together. What has been presented here will allow the economists, botanists, agriculture engineers, and biochemists to move forward in their research. In turn what they learn will help refine land use research.

1. The Aitkin County pilot land use study needs to be refined and expanded. As reactions to this work come back from other researchers and policy makers, new constraints can be added or old ones refined. New models may also result. In addition the models must be tested in other locales with a different environment. Adjustments can be made and initial estimates generated of the percent of the state's wetland base which might be available for development.

2. Wet planting and harvesting technology must be seriously researched. Access to water for flooding and to water bodies for draining is too restrictive. In Aitkin County, 44 percent of the wetland resource is eliminated because it is more than one mile from a permanent stream or lake. Even where lands are in proximity to water, gaining state permits for withdrawal and discharge may be difficult.

3. Other options might be researched to overcome the problem of water access. Efficient pumps might increase economical access distances. Perhaps careful study of local topography might resolve the water issue. Basins could be used to hold discharged waters until the wetlands need to be reflooded.

4. Economists must help decide what size of operations will work best. Assuming both large and small scale operations are viable, what is the minimum viable size for each? What is the optimum? The answers to these questions will help decide how

many wetland acres will be available for biomass development. Given these sizes, we must also determine whether viable managements can be comprised of non-contiguous lands.

5. A highly efficient technology for converting biomass to a form which could be easily transported, would greatly increase the chances of biomass development becoming a reality. How large must an efficient system be?

6. What would be the social, economic, and environmental impact of biomass development? Which counties with a wetland resource are rural, not wealthy, and have limited infrastructures? Could they tolerate a large new industry?

7. Botanists need to determine the best local conditions for growing biomass. This will help other researchers. Before too long, it is hoped to establish a pilot development. Improved land use analysis will be used to help select a site.

Policy Issues

If federal, state, and local governments wish to encourage a wetland biomass industry, they will face a number of important policy issues. Some of these issues involve encouraging the industry. Others involve minimizing negative side effects of this development.

1. The county has control over most local land use decisions through its zoning ordinance. In administering the ordinance, the county can decide whether to encourage or discourage wetland biomass development. If it does decide to encourage this development, it must be careful to preserve the protection of its citizens, a crucial element of the zoning ordinance.

2. As an owner and controller of a very large portion of the wetland base, the state of Minnesota must decide whether biomass production is an appropriate use of its lands. It must also decide whether this is the best use.

3. If the nation or the state of Minnesota is truly interested in reducing dollar outflows to pay for liquid fuels, research and development dollars must be provided to make the alternative fuels available from biomass a reality. More publically supported research and development is necessary before farmers and firms will be convinced to get started with biomass development.

4. Will biomass development be given tax breaks? Emphasis in this paper is properly placed on the property tax, but other taxes may be more important to the viability of this industry. Is the public good served by favoring biomass development?

5. If peat extraction is eventually allowed and subsequent biomass development desired, policies must be developed to assure adequate reclamation following the peat mining.

6. Will the state be permissive in allowing water appropriation and discharge? If so, specific new laws may be required. If not, researchers must be more concerned about developing technologies to plant and harvest in wet fields.

7. Wetlands may be drained to produce standard crops for fodder or biomass. Since these wetlands offer flood protection, is government willing to risk the environmental impact of drainage?

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